of small dimensions, is very durable, and not liable to the attacks of insects. It is a very pretty tree. In Japan an oil is made from the kernel of the nut of T. nucifera, and used for culinary purposes. It is a very handsome tree.

ART. XIV.—*On Railway Gradients.* By WILLIAM AUSTEN ZEAL, ESQ., C.E., Melbourne.

[Read before the Institute, 2nd September, 1857.]

MR. PRESIDENT AND GENTLEMEN,—The discussion of a subject of so much importance to every colonist in Victoria, cannot be considered at a more opportune time than the present; and, no Institute in this province, can with greater advantage to the public express its opinion at this particular crisis, than this Society can now do.

Impressed with this idea, I have written this paper, being convinced no undertaking will have more influence on the future well-being of this great country, than the extension of Railways throughout its length and breadth. This I conceive to be a sufficient incentive for my claiming for it all the publicity so important a question demands.

Victoria, in fact the whole Australian continent, must rely upon, and find in Railways the one great means by which the interior will be rendered available for colonization. Denied the advantage of water carriage, like that possessed by all other countries, an artificial mode of intercommunication must be resorted to, and the Railroad will be called upon to undertake the united duties of Road and River; and from all former experience no better agency can be employed, no more expeditious mode of transit could here be initiated, than that offered by the Railway system.

It is well-known when Railways were first introduced in Britain, the observance of this fundamental law was rigorously enforced;—that the surface of the Rails should form as nearly as practicable a horizontal line and for a lengthened period it was deemed impossible to ascend an incline by locomotive power, except under the most favourable circumstances.

Corroborative of this fact, is an instance patent to all conversant with Railway History; viz.: the virulent opposition the English South Western Company experienced at the hands of the

Great Western proprietary and opposing Landowners of the District, on account of the introduction of inclines scarcely perceptible to the eye. So formidable a character did the opposition assume, that Dr. Lardner was commissioned by the first-named Company, to undertake a series of the most elaborate experiments on the economical working of Railway Gradients. Much time and research were expended in investigating a subject ridiculed by opposing partizans; and, in reviewing the subject it is interesting to observe the bias and prejudice that interested motives will lend to questions demanding the utmost calmness and deliberation in discussion. The inclines, about which so great a controversy arose, were those of 1 in 250. Dr. Lardner, in carrying on his experiments, proved, that in the working of a Train, the velocity acquired by *Gravity* alone in descent, was a compensating feature in favour of grades, producing a result nearly equivalent in value to the increased power incurred in performing an ascent of equal ratio: recent experience has established this an axiom.

Tracing the growth of Railways, and their gradual extension into remote mountainous districts, it is pleasing to note how readily the Locomotive adapted itself to circumstances; how the opponents of severe inclines modified their views, and became the foremost in the van of improvement.

As an example of level lines in England, the London and North-Western, and Great Western, stand pre-eminent. On the latter it has been frequently remarked that the cuttings are so level they are with difficulty drained.

In the United Kingdom, as a general rule, Gradients of a very favourable character prevail, and only in exceptional cases the reverse is the case.

In the United States of America there are Railways upon which inclines of unprecedented severity have been introduced: and American Engineers have in these cases, with national energy, outstript all previous experience. I shall presently quote the cases to which allusion is made; before doing so, however, I would observe that, as a rule, Gradients on American lines are of a favourable character.

On the continent of Europe some interesting innovations of Railway experience have been made; long steep Gradients have been adopted with entire success. Such are found to be capable of economical working, with heavy goods trains, and this, too, combined with speed; results highly encouraging to the Engineer in countries possessing physical difficulties.

The particulars of these, and other successes of engineering skill and enterprise, I shall notice, and produce data to prove that in Victoria the difficulties the engineer has to encounter have been far surpassed in Europe and America; and, I will endeavour to show that we have everything to hope for, and nothing to fear, in the extension of Railways over the entire surface of this province.

Gradients are practically injurious and detrimental to the efficient working of a Railway, when they involve such an increase of power as to render it necessary to resort to the heaviest engines—most substantial permanent Way and Works—greatly reduced rate of speed with increased risk and loss of time to the passenger.

A very severe descent may be accomplished with speed and safety, if the direction of the Railway be in a straight line; but, if combined with curves of small radii, as is often the case, the utmost caution is necessary to prevent the engine leaving the rails. I am fully aware that the limit of grades and curves is a debateable point with engineers, and shall therefore confine myself to laying before you an epitome of British and Foreign Gradients, and describe the result of my own experience, commencing with a brief description of British lines.

The Railways of the United Kingdom are singularly free from abrupt inclines, no expense having been spared in their construction; consequently, they are capable of being worked at high speeds, and with little excess of power beyond what a perfectly level line would require. The economy of this is questionable: for if on a line of 100 miles it can be proved that by the introduction of more severe inclines, both time and money can be saved, I think it will be generally conceded that the economical method is preferable.

The question hence arises, what shall be the limit to inclines? This must be governed by the physical contour of the country. I should not hesitate, however, to introduce a severe gradient where necessity required it, in preference to following a more circuitous route, for, taking the increased length of line into consideration, the extra length of road to lay down, and keep in repair, it will be found far cheaper and preferable to introduce a gradient of (say), 1 in 50, over a distance of two miles than to extend a Railway over three times that length for the purpose of obtaining a gradient of 1 in 150.

The opponents of severe inclines urge, and with some apparent truth, that the increased weight of the engine, competent to work a severe gradient, (say) 1 in 50; so destroys the road as to render it necessary to relay the same, and at intervals renew it with frequent repairs. If it were imperative upon Railway Companies to have these heavy engines, I fully admit there would be every reason in such argument: but when daily experience entirely controverts this fallacy, little weight should be attached to it. The fact is patent to all who have thoroughly investigated the question, that the rails on severe inclines, are but little more subject to wear and tear than those on the most modern ascents.

On a gradient of 1 in 50, two engines of 25 tons*, and 29 tons* respectively, will draw as heavy a load as a single engine of 54 tons.* They can be so constructed that one driver and stoker can attend to both and have also this great advantage over a single engine, that the weight of 54 tons* can be diffused over twice as many wheels as the 54 ton* engine can possibly have. In case of accident likewise, two engines are far safer; one engine being sufficient to control the train, should it be necessary from accident, to return to the starting place.

On the Birmingham and Gloucester Railway;—the Lickey incline,—a gradient of 1 in 37; two engines weighing respectively 35 and 32 tons, or together 67 tons, took up with ease a load of 240 tons at a speed of nearly 7 miles per hour; and on the Turin and Genoa Railway two engines of 25 tons, or together 50 tons, took a load of 100 tons, or inclusive of engines 150 tons, up an incline of 1 in 36 for 6 miles at a uniform speed of 15 miles per hour.

In addition to instances bearing so directly on the economical working of heavy grades, I am enabled to add the results of experiments, undertaken on behalf of the East Lancashire Railway Company by Mr. Perring.

The Accrington Incline is 2 miles in length, composed of the following heavy gradients:—

1 in 40	1.125
1 in 38	.60
1 in 47	.275
	2. miles.

The Report states the experiments were conducted with great care, and extended over a period of three months during the most inclement season of the year.

As it would take much too lengthened a time to analyse each

* Inclusive of tender.

result, I shall give a summary, deduced from experiments made by a single engine, and by a leading and assisting engine, combined :—

GOODS TRAINS.					
SINGLE ENGINE.			TWO ENGINES.		
No. of Trips.	Mean Load in Tons.	Speed. Miles pr hour.	No. of Trips.	Mean Load in Tons.	Speed. Miles pr hour.
196	57.1	5.73	74	117.2	5.49

The weight of the heaviest engine used was 26.25 tons, tender 16.75 tons, 18 inches cylinder, two feet stroke, six five feet wheels, all coupled.

PASSENGER TRAINS.					
SINGLE ENGINE.			TWO ENGINES.		
No. of Trips.	Mean Load in Tons.	Speed in Miles pr hour.	No. of Trips.	Mean Load in Tons.	Speed in Miles pr hour.
24	23.26	19.33	99	28.41	18.89

The heaviest leading engine used weighed 18.5 tons ; tender, 12.5 tons ; 15 inches cylinder ; 1 ft. 8 inches stroke ; 6.5-feet 6 inch wheels, four coupled.

The average weight of the assisting engine was 21.5 tons.

The conclusions deducible from these experiments are, that, where heavy trains have to be moved at low speeds, two engines will perform a duty equal to that undertaken by one engine with half the load ; but in the case of passenger trains, where the power of one engine is equal to the efficient propulsion of the train at a speed of (say) 20 miles per hour, the use of two engines is rather disadvantageous than otherwise.

This is conclusive evidence that the working of severe Gradients has frequently been but imperfectly considered. The following severe Gradients on British, European, and American

[illegible]

[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

Atmospheric resistance, increasing with the square of the the velocity of the moving body, assumes a power on a carriage moving at a speed of one hundred miles per hour, equal to that expended in overcoming the inertia of 180 tons on a level. It is to be regretted, this subject has not received, at the hands of engineers, that amount of consideration its importance demands.

Mr. H. Bessemer gives an account of a series of experiments on the opposing power of the atmosphere. The conclusion he arrived at was, that the resistance of the atmosphere equalled on the leading carriage of a train, a power of 10 to 4, as contrasted with the resistance offered individually by each trailing carriage. Continuing these experiments he states—this latter force was completely neutralised by filling in the spaces between the ends of each carriage with hoods, making the train in appearance one long carriage.

This report is singularly at variance with the statements of Mr. Wood, published by the British Association. There it is stated, "the form of the front," (*i.e.*) the leading carriage of a train "has no observable effect, and that whether the engine and tender be in front or two carriages of equal weight, the resistance will be the same."

It is further shown, that "converting the train into one unbroken mass," by filling in the spaces between each carriage, as adopted by Mr. Bessemer, was a "*disadvantage*" rather than otherwise, and Mr. Wood concludes, "it is certain that no additional resistance is occasioned by leaving open spaces between the carriages."

How such conflicting accounts can be reconciled, is a question I will not discuss. Possibly Mr. Wood's experiments were made on a comparatively calm day, with the motion of the air uniformly with that of the train.

I am inclined to think, that with a head wind, however slight, the theory of Mr. Bessemer is the most accurate one, though, doubtless, the results quoted are much exaggerated.

According to the Chevalier de Pambour, the resistance of the atmosphere to the passage of a train may be found thus :—

V=Velocity of moving body, $V^2 \times \cdot 002688$=Atmospheric resistance in lbs. avordupois per square foot.

On a level well laid line of railway, *Friction* retards motion to the extent of 6lbs. per ton for carriages. This may be assumed as a constant.

The resistance due to *Gravity*, when the line of traction is parallel to the incline, increases in uniformity with the grade, and equals, in an incline of 1 in 50, 44.8 lbs. per ton; hence, the surplus of traction in a train of 150 tons, ascending an incline of 1 in 50, on account of grade, is 6720 lbs., or equivalent to the force an engine requires to exert in moving 840 tons on a level.

It would be but travelling over ground, thoroughly investigated, to enter fully into the question. of resistances Peculiarities of climate and temperature occur in every habitable portion of the globe. In England, the frosts, fogs, and mist, are very detrimental to the expeditious ascent of inclines, and involve a serious loss of power on the average working of Trains.

In Victoria, I do not anticipate from these causes, any material loss, the climate is more genial, clear, and dry; in summer the heat of the furious Sirocco from its rarifying qualities, will assist, rather than retard the engine, in climbing the steep sudden ascents peculiar to this country.

The full solution of the subject of gradients involves the consideration of the question:—what incline gives practical assistance to a descending Train?

The *angle of Repose* has been assumed by various authorities of inclinations, varying from 1 in 280 to 1 in 380; the latter is an American standard.

This is a question of great mathematical interest, and would require too much time to enter upon fully. I am, however, inclined from continued observation, to think the angle of repose should be more acute than either of these inclines. It is true, in practice, it cannot be supposed that any machine or moving body can be made so perfect in form and finish, that it will from a state of rest, move by force of gravity on an incline more acute than 1 in 280, and run downwards with accelerated velocity; still, I have no hesitation in affirming, that the time will come when the practice and theory of this subject will much more closely assimilate than they now do.

The Irish Railway Commissioners assumed, that a descending grade of 1 in 140, imparted an impetus to a train, of practical value, but with a greater incline no advantage was gained as regards speed. From my own experience, I am led to infer, that this standard is far too high, and should be about 1 in 100.

The compensating power of descending planes, is an element in their favour of the greatest importance, it being found that the cost of the additional power required of an engine in ascent, is nearly counterbalanced by an equivalent obtained in descent, where a greater speed at a reduced cost is a natural consequence.

I need but refer to home authorities confirmatory of this assertion, and point to what Engineers, formerly adopting the "level theory," have in later years done.

Mr. Brunel, in a report to the Great Western Directors, dated December, 1838, strenuously advocates "the great superiority of a line "approaching the level," and further states, "On gradients of 16 feet per mile, the engine during half the time is barely doing more than driving itself." In 1850, we find him adopting gradients of *eighty-five and one hundred feet per mile with entire success.*

Regarding the expense of working inclines, Mr. Vignoles, in a paper read in 1840, before the members of the British Association, states, "he had analysed railway expenses of working, and reduced them to a mileage, &c., as deduced from several years experience &c., under different circumstances, and with greatly different gradients;" and he adds, the result of "this average seemed to hold good *irrespective of gradients or curves.*"

Dr. Lardner gives an elaborate analysis of the working of railway gradients: the result is so well known, I shall but allude to it. He asserts that "a compensating effect is produced in descending and ascending gradients, and that a variation of speed in the train is the whole amount of inconvenience that will ensue; that the time of performing the journey will be the same in both cases." I must, however, admit that the gradients, to which the learned doctor alludes, are of the class now known as "*favourable,*" or flatter than 1 in 140; still, I fearlessly assert, that even on ascending and descending planes, where gradients of one hundred feet per mile are used, the loss of time and speed will not amount to more than 30 per cent., under disadvantageous circumstances, as contrasted with a level line. This result I obtain from the working of English railways.

In 1845, the Board of Trade report that "such gradients as were before thought objectionable, are now adopted every day as a matter of course; and as the capabilities of the locomotive have been enlarged, gradients of a class which would have been a few years ago altogether impracticable, have come into general use."

Many statements have been hazarded relative to the increased friction of descending planes on curves, contrasted with a direct line. No practical result, however, of sufficient moment has been elicited that will decide this question.

From my own experience I am clearly of opinion, where the permanent way is well laid, sufficient play being allowed between the flanges of the wheels and the gauge of way, and the outer rail sufficiently raised to counteract centrifugal force, that the difference of friction on an inclined plane, by curves of not less than half a mile radius, or by straight line, is of very trifling value, and would be, perhaps, barely perceptible.

I have purposely refrained from entering at length upon the working of gradients, contenting myself with furnishing the most striking results of experiments on lines bearing analogy to those of Victoria; and, shall now commence a description of the physical peculiarities observable, in prosecuting the railway surveys in this province.

Having been professionally engaged for two years, examining this colony for the purposes of railway communication, I feel I am entitled to speak in a more authoritative manner, than I should otherwise be justified, and shall now give a hasty sketch of the features of the country examined in selecting the routes of our railways. I most sincerely hope that the discussion of this subject will be full, free, and explicit; as it will tend to throw much information on what is now a vexed question.

Before entering upon an exposition of the necessary inclines on the trunk lines of railway in this province, it will be imperative upon me to describe the physical peculiarities which exist in various localities.

A very general conviction has hitherto existed amongst all classes, professional and otherwise, that this country is peculiarly adapted for railways, on account of its level character. In illustration of this, I beg to refer you to the report upon Internal Communication, by the Commissioners appointed by Mr. La Trobe; in which you will find this statement fully verified. I shall hereafter show how incorrect has been this supposition, and how entirely the reverse is the case. One gentleman has lately written a very able pamphlet on railway economy, and has endeavoured to prove, that because a point inland 47 miles, is 1886 feet above low water, Hobson's Bay, the "*necessary gradient*" is only 1 in 131. The point in question, to which allusion is made, is the apex of the dividing range near Mount Macedon; and by the rule the author lays down, the necessary gradient should be 1 in 118, as neither the height nor length is correctly stated; the former being 1911 feet, and the latter 43 miles. Again, the "*necessary gradient,*" on the line to Kilmore, is stated to be 1 in 208, it should be 1 in 138 the length being 31 miles and height 1188 feet. It is further stated, "there is no necessity to go over the ranges at the high points selected." This is an assumption not in the power of the writer to prove, as I fearlessly assert that in all adopted lines permanently surveyed, the lowest crossing of the range has been a desideratum imperatively enforced. The lowest *practicable* crossings of the range *have been found.*

In another pamphlet, addressed to the Melbourne Chamber of Commerce, the writer in sketching out proposed routes of lines to the Gold Fields, states :—" It is evident therefore, that the best course would be by Keilor to Gisborne, letting the line diverge from Gisborne to Ballaarat, as near as possible to Blackwood on one side, &c."

I imagine, the author could not at the time of writing this, have ever left the immediate vicinity of Melbourne: as I venture to declare that a more impracticable country than that from Gisborne to Ballaarat *via* Blackwood, cannot be found on the face of the earth: range towers above range, and precipitous gullies are replaced by broken craggy cliffs and rocky chasms. Examining this country from the valley of the Lerderderg, this truth is strikingly apparent, and every one who knows the locality will fully acquit me of the slighest exaggeration.

Persons having a knowledge of the interior of this country, are aware how singularly abrupt and sudden is the rise of the table land. I cannot offer a better illustration corroborative of this fact, than the country in immediate contiguity to Bacchus Marsh, where the table land rises from an elevation of 500 feet, to an altitude of 1330 feet above low water, Hobson's Bay; and this occurs in a distance of 6½ miles. The ruling gradient, according to a rule before quoted, is here 1 in 41.

The Gold Fields of Victoria, are nearly all situate to the north of a high mountain range traversing this province from east to west. Possessing the attractions of wealth, population, and enterprise, they naturally constitute a most important feature in considering the routes of lines; and, as no railway can approach them without first crossing this high land, familiarly known as the *Coast Range*, it becomes a matter of great interest and no small moment to the engineer, to know which is the most favourable point for doing so. In describing the contour of Victoria, on either side of the mountains, I shall commence by glancing at the country immediately south of them, taking Melbourne as the great centre from which all lines will radiate.

Melbourne appears, on a cursory examination of the map of this colony, to be the centre of a vast amphitheatre, the outermost confines of which is the Dividing Range, most distinctly marked in the distant horizon. To the north-east is Mount Disappointment and the Plenty Range, ending a view at once bold and picturesque; to the north-north-west towers Mount Macedon, the Olympus of the forest: massive, abrupt, and grand, even in shadowy outline, beyond whose heights the eye cannot wander; to the west is Mount Blackwood looming in the distance, a landmark almost as familiar as Macedon itself. These mountains are all situate and form the apex of the Watershed, from whence all the rivers in Victoria take their rise; those to the north draining into the Murray, and those to the south following their various ducts to the sea.

Between the Coast Range and Melbourne, another peculiarity in the features of the country occurs, presenting an outline scarcely less marked than the coast range. This has been found an equal, if not a greater obstacle to encounter. What I allude to is the sudden elevation of the Table Land at the extreme boundaries of the plains and entrance to the timbered country. This singular freak of nature is more prominently marked in some localities than others, but still preserves its entirety of character, approach it in whatever direction you may. To the north, it stands up in high relief and bars the way; at Sunbury, or north-west, it is again observable, and here prominently so, the plains on the south-west side of Jackson's Creek being 1209 feet above low water, Hobson's Bay; whilst, in a northerly direction, 4 miles distant, a rise of 300 feet has been effected. In the west at Bacchus Marsh, it forms the Pentland Hills; is again observable at the Anakies; then at the Moorabool, and still in the far west.

As I before stated, this sudden rise in the table land presents to the Engineer a difficulty second only to the passage of the dividing range, and is a point to which I will especially draw your attention.

I now ask you to follow me, whilst endeavouring to pourtray the salient features of the country, between the coast range and the Murray.

The Murray forms the channel into which all the waters of North Victoria drain, and presents on all sides the lowest ground in the interior: hence, it may be inferred, that the summit of the hills being passed, no obstacles will present themselves in following a northern route.

This, however, is not the case, as will be apparent to any one who has possessed himself of the information on this head, in the Railway Report of the Honorable the Surveyor General; there, it is most clearly shewn, that the difficulties of ascent and descent do not cease, until the level plains are reached; a point some miles north of Bendigo. On the summit of Mount Alexander this opinion can be readily tested; from it will be seen the intricacies of the country, extending from Mount Beckwith on the west, to a point many miles east of Mount Camel.

This large tract of country appears broken and rugged; is traversed with ranges and gullies of a most formidable character; and many of the abrupt declivities far exceed those on the sea-board side of the mountains.

North of Bendigo, from east to west, the plains extending to the Murray afford every facility for the construction of Railways. In illustration, I may state, that on a line of upwards of 46 miles, the descent is only 204 feet, giving a ruling gradient of 1 in 1199.

Having as briefly as possible glanced over the features of the country, between Melbourne and the Murray, I will describe the leading difficulties to be contended against, and shew the means adopted to insure the most perfect routes.

In conducting the Railway Surveys in Victoria, two large parties were established under the guidance of the Engineer-in-Chief. The instructions in all preliminary surveys were to obtain the most efficient working gradients and if time did not permit the survey of alternative lines, transverse sections of the country were to be taken, with a view to the ultimate improvement of routes, when the permanent survey was decided upon. If a great difficulty of obtaining an easy gradient arose; as at Sunbury, Bacchus Marsh, the Moorabool and again on the "Range" as at Kilmore, East Macedon, Woodend, the heads of the Loddon and Werribee, and Jowerrk Jowerrk, near Ballaarat, the most extended surveys were made, and lines run in every possible direction to ensure the most favourable passage of the mountains. Professional men will believe this, when I state, that a transverse section of the country has been taken between Macedon and Mount Blackwood and over all points upon which a doubt could be raised. Many minor features, have doubtless, not as yet received that attention they require, from the fact, that the permanent survey in those localities has not been decided upon. When that has been done, I have no hesitation in affirming, that the best workable line will be the one selected.

As in theory, the most perfect line is that which is uniformly straight and level: so have the permanent surveys of Victorian lines been laid down, to approximate as closely as circumstances would admit, to this standard.

In Victoria, many difficulties intervene between points which cannot be overcome by either a long cutting or a tunnel; and in exemplification of this I would instance the country immediately south of the Pentland Hills. To obtain a line from Melbourne to Ballaarat this point *must* be passed; and a sudden rise of 800 feet has to be overcome in 6½ miles: and even after this summit is attained, the rise continues for some miles at an inclination of 1 in 100. The most natural conclusion for the public to arrive at is—*circumscribe the hills, and lengthen the gradients.* This would be perfectly true and in accordance with all precedent could it be successfully carried into practice; but in the instance quoted, at Bacchus Marsh, we were placed in this dilemma :—On the north bank of the Werribee a most impracticable country occurs from Bacchus Marsh to Ballan, between the Werribee and Glenmore (Griffith's station), a distance of 1½ miles. A high flat topped mountain ridge intervenes, intersected with a deep ravine bearing a perfectly serrated appearance, and precluding the possibility of "winding round the hills" as has been frequently suggested. The valley of Glenmore then occurs, flanked on either side by basaltic cliffs, descending precipitously several hundred feet; and, branching off to the south-west, a mountain range springs up and stays all progress there.

It has been found at this point, after surveys of the most elaborate character have been undertaken, that it is impossible to ascend from the Barwon Creek, to the Iron Bark range, near Ingliston, except by the introduction of gradients of not less than 1 in 50, to 1 in 60.

In England, a watershed like this, rises suddenly and abruptly. Generally speaking, it can be pierced with a tunnel and there the difficulty ends; but in Victoria, the Railway, must rise with the table land, and have its contour governed by it. From Melbourne to Bacchus Marsh, no difficulties of gradients occur; the rise is most favourable and gentle, and from Ballan towards the coast range, no difficulty arises, demanding special comment.

At Sunbury, close to Clarke's special survey, a difficulty of similar character to that at Bacchus Marsh occurs, which must be overcome by the introduction of a steep incline. After this the table land ascends uniformly easy till Gisborne is approached.

Between Gisborne and Woodend the Macedon range has to be crossed, a ride through the Black Forest acquaints the traveller of its peculiarities better than any written description will do. It has the same peculiarity of ascent previously noticed; and although the most careful surveys have been made, and the country thoroughly explored for miles on either side of the mountains, it has been found necessary in the crossing of this natural difficulty, to adopt a steep incline.

It would take too much time to describe the various summit levels occurring near Kilmore, on the north eastern line—at Elphinstone, at the Porcupine and the Alexandrian range, on the Mount Alexander line—at the head of the Werribee, at Daylesford and Mount Franklyn on the North Western line—at Jowerrk Jowerrk, Yandoit, and the Limestone Creek on the west line and at the Moorabool, Buninyong and Warrenheip, on the Geelong and Ballaarat line. This information is obtainable in the report of Captain Clarke; suffice it, therefore, to say, they partake of a similar nature to those previously enumerated, and are difficulties in the way of obtaining a comparatively perfect line which cannot be overcome.

Some idea of the importance attached to the subject of Railway Gradients in Victoria, may be gleaned from the extended surveys made. The public cannot be aware of a tithe of the information collected. When I state, however, that more than 120 miles have been permanently surveyed, 1200 miles of Railway temporarily surveyed, and nearly 2000 miles of tranverse sections taken, it will be conceded, I think, that the question has not been slurred.

Many of these sections have been taken over ground not previously surveyed, and an estimate may be formed of the difficulties the engineer had to encounter in travelling over ground little known; nevertheless, the coast range has been thoroughly examined, from a point some miles east of Mount Disappointment to the country far west of Ballaarat; and its most favourable crossing for Railway purposes has been by gradients of 1 in 60 to 1 in 78, near Kilmore. Unfortunately, this is on a line far to the east of the direct approach to the Gold Fields, and would involve a most circuitous route to be made available for that purpose.

It is evident, that the disadvantages Victorian Railways will labour under, are those of heavy inclines; experience, however, has fully proved, that grades far more severe, occurring in Europe and America, have been, and are daily worked to advantage; and, it is not too much to hope that the improvements daily making in the rolling stock of railways, will enable the most unfavourable inclines, to be worked with far greater speed and less loss of power than at present they can be.

That Railways will do much for Victoria has never been denied:—that her resources will increase and multiply beyond all precedent:—that her mineral wealth will be developed to an extent unparalleled in the world's history is not too much to be expected.

Her beautiful park-like scenery, clothed with a velvet sward, and luxuriant with vegetation; her plains abounding in the richest soil now wild and tenantless and her lightly timbered woods and forest land, where the prolific virgin earth has never been disturbed, offer inducements to the settler unknown to other colonies, but now rendered unavailable for want of communication with populated districts.

In conclusion, I would add, that I have written this paper with the hope that more attention will be paid to the subject of Railways than has hitherto been done, and to describe the physical peculiarities existing in Victoria, probably unknown to a majority of the inhabitants of Melbourne.

ART. XV.—*Recent Discoveries in Natural History on the Lower Murray.* By WILLIAM BLANDOWSKI, ESQ.

WITH FOUR PLATES.

[Read before the Institute, 2nd September, 1857.]

[*Preliminary Report (No. IV.), Addressed to the Honorable the President of Public Lands and Works. By order, handed over to the Philosophical Institute.*]

GENTLEMEN,—The Honorable the President of the Board of Public Lands and Works has permitted me to lay before you the results of my investigations from the 1st of December, 1856, to August, 1857. It would be impossible for me to give you, at this present moment, a full account of all my observations; therefore, accept the brief outlines I now offer to you according to your request made to the Government.

In order that you may understand more fully the nature of the country which I have traversed, and the difficulties with which I had to contend, and what prospects I had on leaving Melbourne, I beg to read to you an extract of a single page from Surveyor White's Report, dated May 28th, 1849, who surveyed the district visited by me: which document was officially handed over to me before I undertook my late tour.

October 30, 1849.—"Again encamped at Messrs. Baird and Hodgkinson's, having been so fortunate as to obtain a small supply of water by digging in the sand at a certain spot—thus, having been eleven days without water, succeeded in saving the bullocks, with the exception of four, that died, and in bringing